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Final Report  
F-B2303.7

# Technical Report

SENSITIVITY OF THE S01-10307-11 AND  
S01-10307-12 VERSION OF THE APOLLO  
STANDARD INITIATOR TO 9000 MEGAHERTZ  
PULSED ENERGY

(Task No. 7)

by

Paul F. Mohrbach  
Robert F. Wood

September 1966

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
Manned Spacecraft Center  
Houston, Texas

Contract No. NAS9-3787-7

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HOUSTON, TEXAS



THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

BENJAMIN FRANKLIN PARKWAY AT 20TH STREET, PHILA. 3, PA.

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Final Report F-B2303-7  
"Sensitivity of the S01-10307-11 and S01-10307-12  
Version of the Apollo Standard Initiator to 9000  
Megahertz Pulsed Energy"  
Task No. 7  
Paul F. Mohrbach and Robert F. Wood  
September 1966  
for National Aeronautics and Space Administration  
Manned Spacecraft Center  
Contract No. NAS9-3878-7  
14 Pages Including Data Sheets

Dr. J. R. Feldmeier  
Director of Laboratories

#### ABSTRACT

Two groups of Apollo Standard Initiators were evaluated at 9000 MHz, pulsed, in the bridgewire-to-bridgewire mode. One group had a slurry on the bridgewire while the second group did not. The test was conducted at the 0.1% power level and all of the items fired indicating that both lots are more sensitive than the original lot (S01-266-6).

The Apollo Standard Initiators that were non-fires from the RF tests we conducted during May 1965 were also subjected to the 0.1% power level. Six out of ten fired, indicating that the sensitivity of the lot has increased.

Non-destructive tests (parameter measurements) did not reveal any change in the devices when they were exposed to 9000 MHz before firing.

#### ACKNOWLEDGEMENTS

This report was prepared by the Applied Physics Laboratory, E.E. Hannum, Manager. Major contributors were Paul F. Mohrbach, Principal Scientist, Robert F. Wood, Senior Research Engineer and Avvakums W. Cipkins, Technical Associate.

Inquiries pertaining to the contract should be directed to the sponsoring agency or to Mr. E. E. Hannum, Manager, Applied Physics Laboratory, The Franklin Institute Research Laboratories.

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## 1. INTRODUCTION

The purpose of this task is to compare the bridgewire-to-bridgewire RF sensitivity of the S01-10307-11 and S01-10307-12 initiators. These units are the Standard Apollo Standard Initiators (ASIs) except they were not subjected to the hydrostatic pressure test. The two units differ in that the S01-10307-11 has a slurry on the bridgewire while the S01-10307-12 does not. They are to be subjected to 9,000 megahertz (MHz) (pulsed) energy using the 0.1% level reported in FIRL final report F-B2303-1\*. The 0.1% level, 89 milliwatts, was obtained from a forty item Bruceton run on Space Ordnance System's S01-266-6 initiator. Data from the tests on the two new devices are compared with the data from this earlier test.

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\* Paul F. Mohrbach and Robert F. Wood, "Radio Frequency Evaluation of Apollo Standard Initiator," Final Report F-B2303-1, May 1965, for NASA Manned Spacecraft Center, Contract No. NAS9-3787.

## 2. 9000 MHz TESTS

In RF sensitivity tests performed on the standard ASI (S01-266-6) in a previous study (Final Report F-B2303-1, "Radio Frequency Evaluation of Apollo Standard Initiator", May, 1965), the ASI was found to be quite sensitive at 9000 MHz, pulsed,\* and was approximately equally sensitive regardless of whether the RF power was applied pin-to-pin, pins-to-case or bridgewire-to-bridgewire. It was inferred from this that initiation might be occurring in the same manner regardless of where the power was applied; for example, the device might always initiate between the pins and the case.

The main purpose of Task 7 is to determine if the addition of a slurry on the bridgewire affects the bridgewire-to-bridgewire RF sensitivity. In addition we also want to compare both of these with previous ASIs that we have evaluated.

As an example, during task 4\*\*we evaluated fifteen ASIs that carried the identification ME 453-0009-0001. Five of these units were tested at the 0.1% level (0.089 watts) and two fired. This would indicate that these devices are more sensitive than the S01-266-6.

For the purpose of comparison, we have included the results of the tests on the S01-266-6 taken from report F-B2303-1. These data are shown in Table 2-1.

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\* 1.5 microsecond pulse width, 1000 pulses per second.

\*\* Paul F. Mohrbach and Robert F. Wood, "Special Radio Frequency Tests on Apollo Standard Initiator," Final Report F-B2303-4, April 1966, for NASA Manned Spacecraft Center, Contract No. NAS9-3787.

Table 2-1  
9000 MHz TEST ON S01-266-6 ASI (BRIDGE-TO-BRIDGE MODE)

<u>Test No.</u>	<u>Test Freq (MHz)</u>	<u>Power Mode</u>	<u>Power to EED (Watts)</u>	<u>No. Non-Fires</u>	<u>No. Fires</u>
RF-1147	9000	Pulsed	0.15	2	0
		1.5	0.20	1	0
		Micro-	0.25	2	3
		second	0.35	0	1
		1000 PPS	0.50	0	2
Conclusions: Average power mean about 0.25 watts. Peak power mean about 167 watts.					
RF-1148	9000	Pulsed	No. tested = 40		
Bruceton		1.5	Sigma = 0.08482		
Test		Micro-	99.9% (*) = 0.65 Watts		
		second	50% = 0.24 Watts		
		1000 PPS	0.1% (*) = 0.089 Watts		
			Peak power	99.9% (*) = 433 watts	
				50% = 160 watts	
				0.1% (*) = 133 watts	

The first device tested was the S01-1307-12. When five out of the first five fired at what was supposed to be the 0.1% level (0.089 Watts) we stopped the test. After satisfying ourselves that the evaluating equipment was functioning properly and that the calibration was correct, we proceeded using a level of 0.044 watts. Two out of two initiated. We then dropped to 0.022 watts with the results that no fires occurred for the three devices tested. The three non-fires were retested at 0.044 watts and two initiated. The third was then subjected to 0.089 watts and it fired. These retests are not recorded in Table 2-2. It is our practice not to reuse items since we do not know how they are influenced by a previous stimulus.

---

\* 95% Confidence



Table 2-2

## 9000 MHz TEST ON S01-10307-12 ASI (BRIDGE-TO-BRIDGE MODE)

<u>Test No.</u>	<u>Test Freq. (MHz)</u>	<u>Power Mode</u>	<u>Power to EED (Watts)</u>	<u>No. Non-Fires</u>	<u>No. Fires</u>
RF-1435	9000	Pulsed	0.022	3	0
		1.5	0.044	0	2
		Micro-	0.089	0	5
		second 1000 PPS			

The same type of test was conducted on the S01-10307-11 and the results are recorded in Table 2-3.

Table 2-3

## 9000 MHz TEST ON S01-10307-11 ASI (BRIDGE-TO-BRIDGE MODE)

<u>Test No.</u>	<u>Test Freq. (MHz)</u>	<u>Power Mode</u>	<u>Power to EED (Watts)</u>	<u>No. Non-Fires</u>	<u>No. Fires</u>
RF-1434	9000	Pulsed	0.022	3	0
		1.5	0.044	1	1
		Micro-	0.089	0	5
		second 1000 PPS			

Once again we found that the first units tested at 0.089 watts fired. One out of two fired at 0.044 watts and none out of three at 0.022 watts. The three non-fires did not fire when retested at 0.044 watts but did initiate with 0.089 watts as did the previous non-fire at 0.044 watts.

Our conclusions based on these data are that these new devices are much more sensitive to 9000 MHz, pulsed, energy in the bridgewire-to-bridgewire mode than the original ASIs. We conveyed this conclusion to NASA Houston and were asked to do further testing using ten ASIs from the original lot (S01-266-6). Results of this test are given in Table 2-4.



Table 2-4

## 9000 MHz TEST ON S01-266-6 NON-FIRES (BRIDGE-TO-BRIDGE MODE)

<u>Test No.</u>	<u>Test Freq. (MHz)</u>	<u>Power Mode</u>	<u>Power to EED (Watts)</u>	<u>No. Non-Fires</u>	<u>No. Fires</u>
RF-1454	9000	Pulsed 1.5 Micro-second 1000 PPS	0.044	2	0
			0.089	4	4

The two non-fires from the 0.044 watt test were subjected to 0.089 watts and they fired.

Before drawing conclusions from these data it should be noted that these ten items are not new but are non-fires from radio frequency tests RF-1136 and RF-1148 performed during May 1965. It would appear that the previous application of power has made these devices more sensitive in the bridgewire-to-bridgewire mode. To determine if any drastic change had taken place in the dc sensitivity, we subjected the remaining four non-fires to one ampere for five minutes (bridgewire mode). None of the items fired.

### 3. PARAMETER MEASUREMENTS BEFORE AND AFTER RADIO FREQUENCY EXPOSURE

As requested in Exhibit "A" (Statement of Work) of contract No. NAS 9-3787-7 several parameters are to be measured before and after exposure of the ASIs to radio frequency power. These measurements were made to determine the effect of radio frequency exposure on these parameters. After a visual inspection, the quantities determined were: bridgewire resistance, insulation resistance, inter-bridge capacitance, pins-to-case capacitance and bridgewire-to-bridgewire resistance. Results of these observations are tabulated in Tables 3-1 and 3-2. From these data we would conclude that these parameters are not affected by the application of the RF energy.

TABLE 3-1  
PRE-FIRING DATA SHEET S01-10307-12

TEST GROUP: S01-10307-12

DATE: 7-22-66

INITIATOR SERIAL NO.	VISUAL INSPECTION		A - B		C - D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (uMF)		PINS TO CASE CAPACITANCE (uMF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
16	OK	-	1.09	-	1.05	-	3x10 <sup>9</sup>	-	7	-	12	-	1.4x10 <sup>6</sup>	-	Fired
18	OK	-	1.06	-	1.04	-	2x10 <sup>11</sup>	-	6.5	-	11.8	-	5.7x10 <sup>6</sup>	-	Fired
19	OK	-	1.09	-	1.06	-	2x10 <sup>11</sup>	-	7	-	11.8	-	5.7x10 <sup>6</sup>	-	Fired
20	OK	-	1.04	-	1.08	-	0.5x10 <sup>11</sup>	-	8	-	11	-	2.8x10 <sup>10</sup>	-	Fired
22	OK	-	1.08	-	1.05	-	0.7x10 <sup>11</sup>	-	8	-	11.7	-	2.8x10 <sup>10</sup>	-	Fired
23	OK	-	1.04	-	1.09	-	1.5x10 <sup>9</sup>	-	9	-	11.5	-	2.8x10 <sup>10</sup>	-	Fired
25	OK	-	1.05	-	1.05	-	2x10 <sup>11</sup>	-	9.5	-	11.7	-	2.8x10 <sup>10</sup>	-	Fired
27	OK	OK	1.08	1.08	1.09	1.09	1.5x10 <sup>11</sup>	1.09	8.5	8.5	11	11	2.8x10 <sup>10</sup>	> 2.8x10 <sup>10</sup>	
28	OK	OK	1.06	1.06	1.07	1.07	0.2x10 <sup>11</sup>	1.07	9	9	11.5	11.5	2.8x10 <sup>10</sup>	> 2.8x10 <sup>10</sup>	
29	OK	OK	1.06	1.06	1.03	1.03	0.1x10 <sup>11</sup>	1.03	8	8	11	11	5.7x10 <sup>6</sup>	5.7x10 <sup>6</sup>	

17

89 MW

44 MW

22 MW

TABLE 3-2  
PRE-FIRING DATA SHEET S01-10307-11

INITIATOR SERIAL NO.	VISUAL INSPECTION		A - B		C - D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (MMF)		PINS TO CASE CAPACITANCE (MMF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
1	OK	-	1.06	-	1.05	-	$5 \times 10^9$	-	10	-	11	-	$1.2 \times 10^6$	-	Fired
2	OK	-	1.07	-	1.06	-	$2 \times 10^{10}$	-	10	-	11	-	$> 2.8 \times 10^{10}$	-	Fired
3	OK	-	1.05	-	1.07	-	$2 \times 10^{10}$	-	10	-	11.5	-	$2.2 \times 10^6$	-	Fired
4	OK	-	1.04	-	1.09	-	$5 \times 10^9$	-	9.5	-	12.5	-	$2.8 \times 10^6$	-	Fired
6	OK	-	1.08	-	1.10	-	$3 \times 10^{10}$	-	5.5	-	10	-	$> 2.8 \times 10^{10}$	-	Fired
9	OK	OK	1.07	1.07	1.08	1.08	$2 \times 10^{10}$	$2 \times 10^{10}$	6	6	11.5	11.5	$> 2.8 \times 10^{10}$	$> 2.8 \times 10^{10}$	
10	OK	OK	1.03	1.03	1.04	1.04	$1.5 \times 10^{10}$	$1.5 \times 10^{10}$	7	7	11	11	$> 2.8 \times 10^{10}$	$> 2.8 \times 10^{10}$	
11	OK	OK	1.09	1.09	1.07	1.07	$7 \times 10^9$	$7 \times 10^9$	6.5	6.5	12	12	$2.2 \times 10^6$	$2.2 \times 10^6$	
12	OK	OK	1.05	1.05	1.04	1.04	$1 \times 10^{10}$	$1 \times 10^{10}$	6.5	6.5	11	11	$7.2 \times 10^{10}$	$> 2.8 \times 10^{10}$	
13	OK	OK	1.06	1.06	1.06	1.06	$2 \times 10^{10}$	$2 \times 10^{10}$	7.5	7.5	11	11	$> 2.8 \times 10^{10}$	$> 2.8 \times 10^{10}$	

TEST GROUP: S01-10307-11

DATE: 7-22-66

1 8 1

89  
MW

44  
MW

22  
MW

#### 4. GENERAL CONCLUSIONS

Comparing the data in Tables 2-1, 2-2 and 2-3, it is obvious that the S01-10307-11 and S01-10307-12 are definitely more sensitive to 9000 MHz (pulsed) energy when applied in the bridgewire-to-bridgewire than the original ASI (S01-266-6) reported in F-B2303-1 and the ME 453-0009-001's reported in F-B2303-4. Whereas the S01-266-6 had a calculated 0.1% level of 0.089 watts, the two new lots *all* initiated at this level or lower.

To help draw conclusions about the effect of the slurry on the RF sensitivity we have rearranged the data in the form shown in Table 4-1. We would be hard pressed to justify the conclusion that the no-slurry group is more sensitive than the group with the slurry based on the extra initiation at the 0.044 watt level and the two during the retest. From the limited data we have, the best we can say is that we cannot see any significant difference between the two groups.

In regards to the test on the non-fires from the original ASI lot (S01-266-6), we cannot say whether the increased sensitivity is due to aging, vibration due to shipping, or that the energy applied during the first tests has increased the bridgewire-to-bridgewire sensitivity. Shorter functioning times were generally observed for retested items. This is usually a good indication of greater sensitivity.



Table 4-1

## COMPARISON OF ASIS WITH AND WITHOUT SLURRY

S01-10307-11 slurry					S01-10307-12 no slurry				
Serial No.	Power (Watts)			Funct. Time (sec.)	Serial No.	Power (Watts)			Funct. Time (sec.)
	.022	.044	.089			.022	.044	.089	
1			X	18.0	19			X	4.0
2			X	54.0	18			X	0.5
3			X	0.04	16			X	11.0
4			X	17.0	20			X	27.0
6			X	6.0	22			X	3.0
9		X		48.0	23		X		6.0
10		0			25		X		75.0
11	0				27	0			
12	0				28	0			
13	0				29	0			
Retest					Retest				
10			X	0.2	27		X		2.0
11		0	X	9.0	28		0	X	0.2
12		0	X	0.6	29		X		38.0
13		0	X	0.06					